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Research Article

Importance of measurement methods and demographic characteristics in evaluating ulnar variance: A retrospective comparative study

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ABSTRACT

Objective: This study aimed to compare 2 methods of ulnar variance (UV) measurement (the perpendicular method and the circular method) and to determine whether UV changed based on the demographic characteristics (sex and age).

Methods: UV was measured on bilateral wrist radiographs of 124 patients (62 men, 62 women; mean age=48.5 years; range=18-79 years) who had no history of trauma, congenital wrist anomaly, previous wrist surgery, and wrist osteoarthritis by a single radiologist with 4 years of experience. All measurements were made on standardized radiographic images using 2 methods: the perpendicular method and the circular method. All the patients were then divided into groups based on sex and age, and the study population was determined by selecting a similar number of patients for each sex and age group.

Results: The mean UV of the right and left wrists was measured as 0.33 (range=−4.3 to 5.7) mm by the perpendicular method and as 0.034 (range=−5 to 5.7) mm by the circular method. A significant difference was determined between the 2 measurement methods ($p<0.001$). There was a statistically significant difference between sex and UV values in the left wrist measurements by both methods ($p<0.05$). A significant correlation was found between the UV and age in both right and left side measurements, indicating a statistically significant difference between the methods ($p<0.001$).

Conclusion: The results of our study demonstrated significant differences in the UV measurement between the 2 methods. Furthermore, UV measurement may change based on age and sex. These differences should be considered in the treatment planning of patients with wrist disorders.

Level of Evidence: Level IV, Therapeutic Study

Introduction

The relative length difference between the radial and ulnar distal joint faces is defined as ulnar variance (UV). It is evaluated as neutral UV (both joint surfaces are at the same level), positive UV (ulnar joint face is more distal), and negative UV (ulnar joint face is more proximal) (1). The relative length of the ulna compared to the radius or UV is seen as an important element in wrist pathologies. This length can be affected by age, genetic factors, load, and elbow pathology (2). Negative UV is associated with Kienböck's disease, avascular scaphoid necrosis, and scapholunate dissociation (2). In contrast, positive UV is detrimental to the ulnar region of the wrist, as it may cause perforation and degeneration of the triangular fibrocartilage complex and erosion of the cartilage of the carpal bones (ulnar impaction syndrome) (2, 3).

Reliable measurements of UV are of utmost importance for surgical interventions, although the preferred method of measurement is still controversial in the literature (4). The value of the UV may vary depending on the position of the forearm at the time of rectification. Accordingly, positive UV value increases at maximum forearm pronation, whereas negative UV value increases at maximum forearm supination. Therefore, measurements are typically performed on graphs taken with shoulder at 90° abduction, elbow at 90° flexion, and wrist in neutral position (1).

Two methods are still widely used in UV measurement: the circular method and the perpendicular measurement method. There have not been enough studies on which of these methods are more reliable. There are also contradictory findings of whether UV is affected by some demographic variables such as age, sex, and sides. Our hypothesis is that these 2 methods will yield different results in UV measurement and are affected by demographic variables.

This study aimed to compare the measurement methods of UV and to provide information about whether UV changed based on the demographic characteristics of patients.

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Materials and Methods

Subject and study design

Bilateral wrist radiographs taken routinely during the diagnostic process of the patients who consulted the rheumatology clinic of our hospital were scanned retrospectively. Patients with wrist trauma, patients with congenital wrist anomaly, patients who had undergone a wrist surgery, and patients with wrist osteoarthritis were excluded from the study. In addition, non-standard wrist radiographs and radiographs in which the measurement area was not displayed well were excluded from the study. The patients, whose wrist was accepted as normal, were divided into groups according to their sex, and the age difference between them was 10 years. The study population was determined by selecting a similar number of patients for each sex and age group.

A written informed consent was obtained from each patient. The study was approved by the Clinical Research Ethics Committee of Akdeniz University, School of Medicine (Date: May 22, 2019 and No: 480).

Wrist plane radiographic imaging

Direct graphic images taken with double-detector digital x-ray devices (USX-RAY, Bolu, Turkey, and Dynamic X-RAY, Ankara, Turkey) were evaluated for both wrists. To determine UV on radiographs, the accepted standard view is a posteroanterior projection obtained with the wrist in neutral forearm rotation, the elbow flexed to 90°, and the shoulder abducted to 90° (5). A 100-cm film-focus distance, 57 kVp, 80 mA, and 5 mAS radiation dose were used as the exposure parameters.

Radiographic measurement

The resulting images were sent to the hospital picture archiving and communication system (PACS), and the images were evaluated with the Sectra Workstation IDS 7 version 20.2 (Sectra AB, Linköping, Sweden). The measurements were performed by a single radiologist with 4 years of experience with this workstation.

Various techniques for evaluating UV have been proposed in the literature (6). To determine UV, measurements were made on direct radiographic images using 2 methods: bilateral perpendicular and bilateral circular (7). In the perpendicular method, a line was first drawn along the longitudinal axis of radius, another line was drawn at the apex of the cortical rim of the distal ulnar aspect of the radius, and a third line was drawn at the apex of the distal cortical rim of ulna, the latter 2 lines being perpendicular to the first line. Then, the distance between these 2 lines was measured (Figure 1. a, b). The ulna was named as negative UV if it was more proximal than 1 mm and positive UV if it was more distal than 1 mm. In the circular method, we drew 2 successive circles, one touching the concavity of the distal radial sclerotic line and other touching the distal cortical rim of the ulnar head. Tangential lines were, then, drawn at both these points, and the distance between the 2 was measured (Figure 1. c, d). Likewise, the negativity or positivity of ulnar variance was named (8, 9).

HIGHLIGHTS

- A significant correlation was seen between ulnar variance (UV) and age, which may explain why non-traumatic ulnocarpal impingement syndrome is more common among the elderly.
- A significant correlation was observed between UV and sex on the left side in the measurements using perpendicular and circular methods.
- We believe that the potential lack of techniques in the literature, especially in the circular method, is due to differences in the concaveness of the lunate fossa.

Statistical analysis

Statistical analysis was carried out using the IBM Statistical Package for the Social Sciences Statistics for Windows version 23.0 (IBM SPSS Corp., Armonk, NY, USA). Data were expressed in mean±standard deviation, median (min-max), or number and frequency. The normality assumptions were analyzed using the Shapiro-Wilk test. The differences between 2 groups were evaluated using the Student's t-test. The paired t-test was used to compare the means of UV measured by the perpendicular method with UV measured by the circular method. The Pearson correlation test was performed to examine the correlation between age and UV. A p value of <0.05 was considered statistically significant.

Results

A total of 124 patients (62 men, 62 women; mean age=48.5 years; range=18-79 years) were included in this study.

The mean UV was 0.33 (range=−4.3 to 5.7) mm in the measurements using the perpendicular method for both wrists of the patients. The mean UV was found to be 0.034 (range=−5 to 5.7) mm in the circular method measurements. In addition, the UV values measured by the circular and perpendicular methods are given as the mean value in both wrists (Table 1).

Table 1. Patient characteristics

Variables	n=124
Age (years), mean±SD (min-max)	48.5±18 (18-79)
Sex, n (%)	
Female	62 (50)
Male	62 (50)
Right perpendicular, mean±SD (min-max)	0.35±1.78 (−4.3 to 5.7)
Right circular, mean±SD (min-max)	0.04±1.91 (−5.3 to 7)
Left perpendicular, mean±SD (min-max)	0.31±1.75 (−4.4 to 4.8)
Left circular, mean±SD (min-max)	−0.003±1.86 (−5 to 4.9)

n: number of patients; SD: standard deviation

Table 2. Comparison of ulnar variance by 2 techniques

UV	Perpendicular (n=124) Mean±SD (min-max)	Circular (n=124) Mean±SD (min-max)	p
Right wrist UV	0.35±1.78 (−4.3 to 5.7)	0.04±1.91 (−5.3 to 7)	<0.001
Left wrist UV	0.31±1.75 (−4.4 to 4.8)	−0.003±1.86 (−5 to 4.9)	<0.001
p	0.662	0.719	

n: number of patients; UV: ulnar variance

Table 3. Comparison of age and ulnar variance according to sex

Variables	Women (n=62) Mean±SD (min-max)	Men (n=62) Mean±SD (min-max)	p
Age	48.5±18.1 (18-79)	48.5±18.1 (18-79)	0.996
Right wrist			
Perpendicular	0.45±1.8 (−3.2 to 4.2)	0.25±1.76 (−4.3 to 5.7)	0.524
Circular	0.17±1.87 (−3.2 to 4.8)	−0.1±1.97 (−5.3 to 7)	0.435
Left wrist			
Perpendicular	0.62±1.69 (−3.5 to 4.8)	−0.01±1.76 (−4.4 to 2.9)	0.043
Circular	0.33±1.79 (−4 to 4.9)	−0.33±1.88 (−5 to 3)	0.047

n: number of patients

Figure 1. a-d. Schematized perpendicular and circular methods. (a) Right side negative ulnar variance by perpendicular method. (b) Right side positive ulnar variance by perpendicular method. (c) Right side negative ulnar variance by circular method. (d) Right side positive ulnar variance by circular method

Table 4. Correlation between age and ulnar variance

	Age	
	r	p
Right wrist		
Perpendicular	0.165	0.067
Circular	0.217	0.016
Left wrist		
Perpendicular	0.207	0.021
Circular	0.297	0.001

A statistically significant difference was found between the 2 measurement methods (p<0.001) (Table 2). The mean value of UV in the right wrist was 0.35 mm as measured by the perpendicular method and 0.04 mm as measured by the circular method (p<0.001). Similarly, the mean value of UV in the left wrist was 0.31 mm as measured by the perpendicular method and −0.003 mm as measured by the circular method (p<0.001). In addition, no statistically significant difference was found between the UV measurements of the right and left wrist radiographs (p=0.662) using the perpendicular method and the UV measurements of the right and left wrist radiographs using the circular method (p=0.719) (Table 2) (Figure 2. a-d).

On the right side, the mean UV was 0.45 mm and 0.25 mm in female and male patients, respectively, as measured by the perpendicular method. The mean UV as measured by the circular method was 0.17 mm in female patients and −0.1 mm in male patients. No statistically significant difference was found in the perpendicular and circulatory methods on the right side according to sex (p=0.524 and p=0.435,

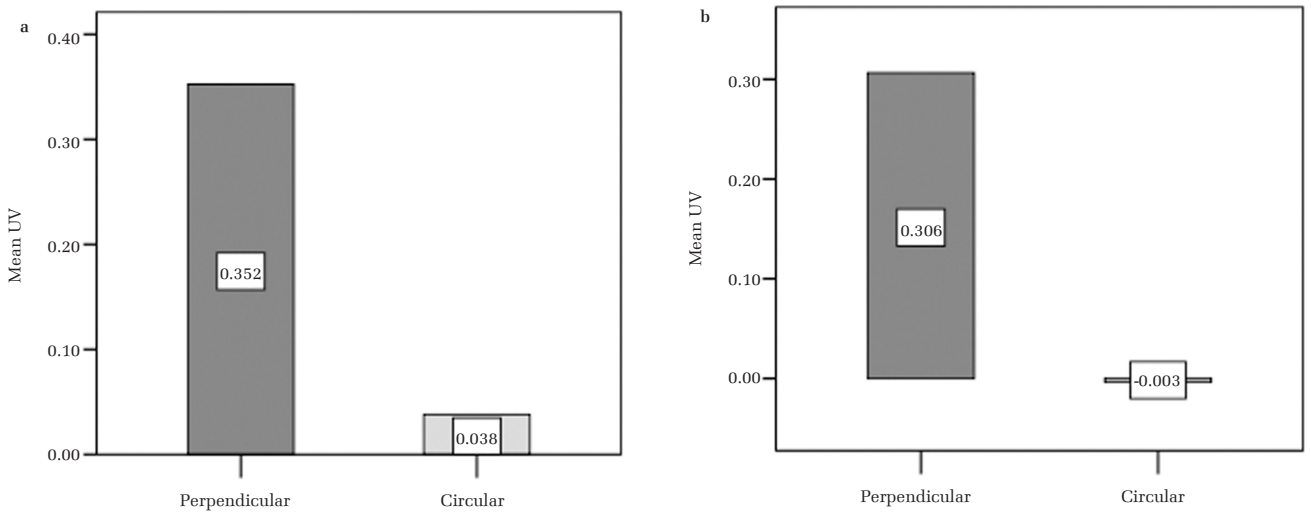

Figure 2. a, b. Comparison of (a) the right wrist and (b) the left wrist ulnar variance by 2 techniques

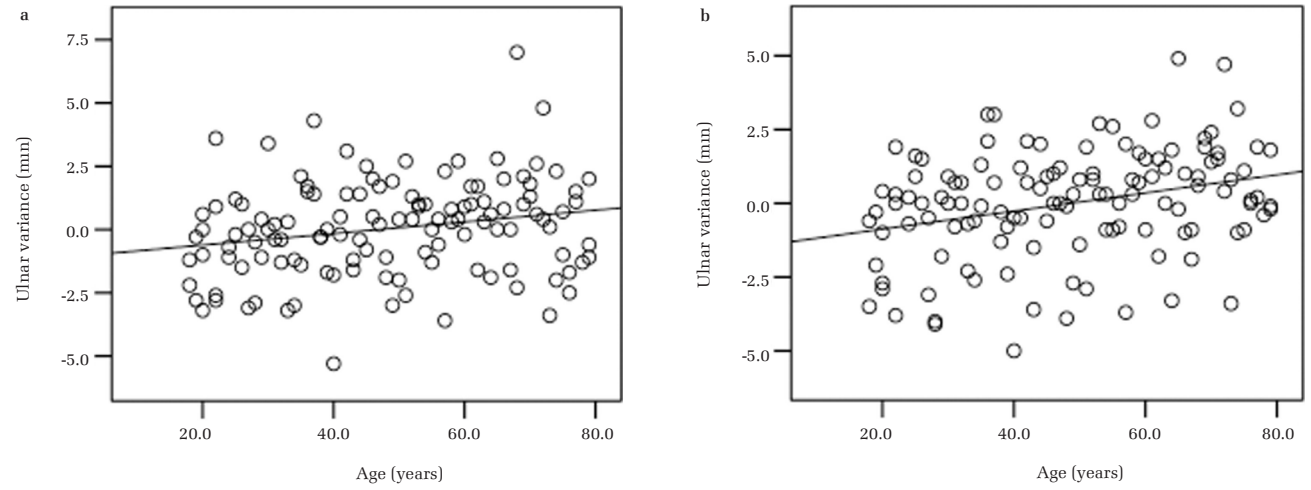

Figure 3. a, b. Correlation between age and ulnar variance in (a) the right wrist and (b) the left wrist ulnar variance measured by the circular method

Table 5. Comparison of ulnar variance by age decades

UV	3rd Mean±SD (min-max)	4th Mean±SD (min-max)	5th Mean±SD (min-max)	6th Mean±SD (min-max)	7th Mean±SD (min-max)	8th Mean±SD (min-max)
Right wrist						
Perpendicular	−0.25±1.6 (−3.2 to 4)	0.4±1.84 (−2.7 to 4.2)	0.25±2.03 (−4.3 to 3.4)	0.4±1.63 (−3.6 to 2.6)	0.95±1.76 (−2.3 to 5.7)	0.48±1.8 (−2.2 to 4.2)
Circular	−0.81±1.67 (−3.2 to 3.6)	0.09±1.91 (−3.2 to 4.3)	−0.11±2.06 (−5.3 to 3.1)	0.18±1.65 (−3.6 to 2.7)	0.77±2.03 (−2.3 to 7)	0.28±2 (−3.4 to 4.8)
Left wrist						
Perpendicular	−0.35±1.83 (−3.5 to 2.7)	0.41±1.45 (−2 to 3.3)	−0.12±1.93 (−4.4 to 2.4)	0.48±1.61 (−3.7 to 2.7)	0.78±1.76 (−2.8 to 4.8)	0.77±1.73 (−3.3 to 4.2)
Circular	−1±1.87 (−4.1 to 1.9)	0.02±1.59 (−2.6 to 3)	−0.43±1.97 (−5 to 2.1)	0.27±1.67 (−3.7 to 2.7)	0.56±1.87 (−3.3 to 4.9)	0.76±1.72 (−3.4 to 4.7)

respectively). However, UV values were statistically significantly different between genders in the measurements on the left side when both the perpendicular method (p=0.043) and the circular method (p=0.047) were measured (Table 3).

Correlation analysis revealed no significant difference in the perpendicular measurement of the right wrist (p=0.067), although there was a significant difference in the circular measurement (p=0.016). However, a statistically significant difference was found between UV and age in the perpendicular and circular measurements of the left wrist (p=0.021 and p=0.001, respectively) (Table 4). The distribution of the mean UV according to age is shown in Figure 3. a, b. The mean values of UV by decades are shown in Table 5.

Discussion

UV measurement is a frequently used method in the evaluation of wrist diseases, understanding the etiology, and during surgical plan-

ning. Therefore, accurate measurement and evaluation may change the procedures to be performed on the patient.

The value of UV is associated with wrist pathologies. Negative UV is one of the most common risk factors for reduced radial inclination, recurrent wrist traumas, disruption of lunate bone geometry, and avascular necrosis of lunate bone in the literature (10). Mechanical factors such as negative UV may cause avascular necrosis of the lunate (11). The length of the ulna does not remain the same throughout life. In addition, previous reports have demonstrated that UV varies depending on age, genetics, load transfer with the ulna, and wrist and elbow pathologies (2, 7). Nakamura et al. found a significant relationship between UV and age in their studies (9). Similarly, we found a significant correlation between UV and age, which may explain why non-traumatic ulnocarpal impingement syndrome is more common among the elderly.

According to our study results, normal wrists and wrists with Kienböck's disease or scapholunate dissociation could be reevaluated by side and sex, as there was a significant correlation between UV and sex on the left side. According to the findings in our study, the mean UV in the right and left wrists using the perpendicular and circular methods was 0.33 mm and 0.034 mm, respectively. There was a statistically significant difference between sex and UV values in the left wrist measurements by both the methods. A significant correlation was found between the UV and age in both right and left side measurements, indicating a statistically significant difference between the methods ($p<0.001$). In this study, a significant correlation was observed between UV and sex on the left side in the measurements using both the methods, in contrast to a study by Elsaftawy et al. (12), which reported no significant correlation between UV and sex. In another study, Nakamura et al. (9) found that the mean UV value was lower in men than in women, consistent with the results of our study.

Although there are various methods to measure UV, none has been accepted with certainty. The perpendicular technique is accepted as the simplest and most suitable method by the majority of surgeons (13). Steyers et al. reported that although the values measured by the perpendicular method revealed more positive results than those measured by the circular method, they were unable to find a statistically significant difference between these 2 methods (14). In our study, a significant difference was observed between both the methods ($p<0.001$), and a significant correlation was found between UV and sex on the left side.

This study had some inherent limitations. The sample size was relatively small, and observers 1 and 2 were not used as the measurements were made by a radiologist. This study also highlighted the basic limitations of using static radiographic images in evaluating UV.

In conclusion, we believe that the potential deficiency of the techniques in the literature, particularly in the circular method, arises from the differences in the concavity of the lunate fossa. We think that the incompatibility between the methods used in the treatment planning of the patients should not be ignored. However, further large-scale, prospective studies are needed to confirm these findings.

Ethics Committee Approval: Ethics committee approval was received for this study from the Clinical Research Ethics Committee of Akdeniz University, School of Medicine (Date: May 22, 2019 and No: 480).

Informed Consent: Written informed consent was obtained from each patient.

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References

1. Cerezal L, del Pinal F, Abascal F, Garcia-Valtuille R, Pereda T, Canga AImaging findings in ulnar-sided wrist impaction syndromes. Radiographics 2002; 22: 105-21. [Crossref]
2. De Smet L. Ulnar variance: Facts and fiction review article. Acta Orthop Belg 1994; 60: 1-9.
3. Pang EQ, Yao J. Ulnar-sided wrist pain in the athlete (TFCC/DRUJ/ECU). Curr Rev Musculoskelet Med 2017; 10: 53-61. [Crossref]
4. Bernstein DT, Linnell JD, Petersen NJ, Netscher DT. Correlation of the lateral wrist radiograph to ulnar variance: A cadaveric study. J Hand Surg Am 2018; 43: 951. e1-951.e9. [Crossref]
5. Sayit E, Tanrıvermiş Sayit A, Bağır M, Terzi Y. Ulnar variance according to gender and side during aging: An analysis of 600 wrists. Orthop Traumatol Surg Res 2018; 104: 865-9. [Crossref]
6. Palmer AK, Glisson RR, Werner FW. Ulnar variance determination. J Hand Surg Br 1982; 7: 376-9. [Crossref]
7. Jalan D, Elhence A, Yadav P. Measurement of ulnar variance in a regional subset of Indian population-A pilot study of 30 subjects. J Clin Diagn Res 2015; 9: 5-8. [Crossref]
8. Chen WS, Wang J-W. Ageing does not affect ulnar variance: an investigation in Taiwan. J Hand Surg Eur Vol 2008; 33: 797-9. [Crossref]
9. Nakamura R, Tanaka Y, Imaeda T, Miura T. The influence of age and sex on ulnar variance. Hand Surg 1991; 16: 84-8. [Crossref]
10. Acar B, Turan A, Köse Ö, Özturk S, Sindel M. Scaphotrapeziotrapezoid arthrodesis using limited wrist fusion plates in Kienböck's Disease. Cureus 2019; 11: e4025. [Crossref]
11. Aydemir AN, Gönen M, Yörükoğlu AC, Yücens M, Demirkan AF. The use of fourth extensor compartment artery bone flap in Kienbock's disease. Eklem Hastalik Cerrahisi 2019; 30:124-9. [Crossref]
12. Elsaftawy A. Radiological investigation of relationship between lunate type and ulnar variance. Pol Przegl Chir 2013; 85: 576-80. [Crossref]
13. Parker AS, Nguyen M, Minard CG, Guffey D, Willis MH, Reichel LM. Measurement of ulnar variance from the lateral radiograph: A comparison of techniques. J Hand Surg Am 2014; 39: 1114-21. [Crossref]
14. Steyers CM, Blair WF. Measuring ulnar variance: a comparison of techniques. J Hand Surg 1989; 14: 607-12. [Crossref]